# Visualizing Integration Uncertainty Enhances User's Choice in Multi-Providers Integrated Maps

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## ABSTRACT

This poster presents an experiment to assess how representation of uncertainty of cartographic integration of multi-providers services is used by end-users[1].



## CCS Concepts

**•Information systems → Uncertainty •Information systems → Location based services •Human-centered computing → Geographic visualization**

## Keywords

Uncertainty Visualization; Spatial Integration; Spatial Entity Matching; Geographic Information Systems; Interface for e-Tourism


In the domain of tourism, cartographic services such as Google Maps, Microsoft Bing, Nokia Here, OpenStreetMap, provide tourists with a way to find points of interest (POI) such as monuments, museums, hotels, restaurants, which are described with *spatial* (location) and *terminological* (e.g., type of POI, phone, price, opening hours, etc.) properties. As the same POI from several providers may reveal inconsistencies, errors and differences, current solutions consist in merging POIs from several providers into one unified map with higher quality [1, 3]. When data of sources are different, the merging process may be *uncertain* (not *confident*). Our study is based on our previous work [1] where the merging process outputs a three-level confidence scale : *lowly* confident, *averagely* confident, or *highly* confident. In this work, based upon recommendations of MacEachrent et al. [2], we selected the most efficient icons to portray spatial, terminological and *global* (spatial and terminological) integration uncertainty. We also identified the recommendation to primarily visualize global integration uncertainty on the icons of the merged POIs, and to pop up on demand information about source POIs from the providers. An illustration of the solution is shown in Figure 1. By clicking on POIs' icons, the user can switch to a mode called “source” mode: all source POIs of the source providers (used to calculate the integrated POI) are portrayed as well as all their source properties. However, one crucial assumption still remains to be checked: is portraying uncertainty useful information for tourists? While looking for POIs through cartographic services, how uncertainty portrayal impacts tourists' behavior? This key question became the goal of a new experiment which is the contribution of this poster.

First, we conducted preliminary interviews with professionals in the domain of tourism: tourist offices of Lyon city, Saint-Etienne city, and Rhône-Alpes Region in France. We elaborated an online form[2] to identify relevant contexts and scenarios, that have been performed by 394 potential users. We identified the most frequently used cartographic services between Google Maps, Mappy, Viamichelin, Mapquest, OpenStreetMap, Géoportail, Bing Maps, and Nokia Here. Google Maps came in first position




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[2] https://sites.google.com/site/unimapuvform (in French)

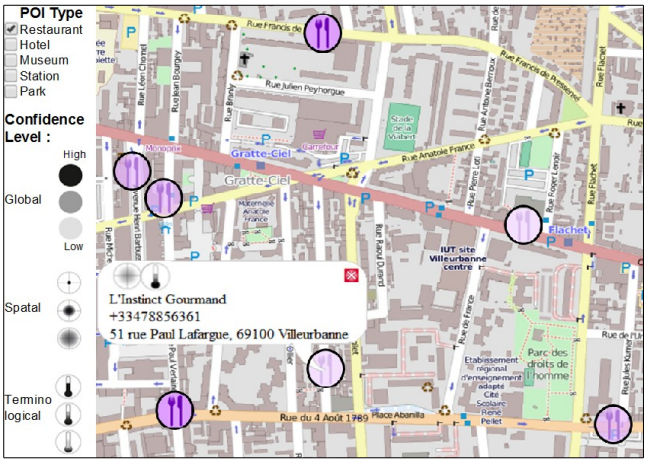


**Figure 1. Integration of POIs from several provider: a solution to portray spatial, terminological and global integration uncertainty [1].**

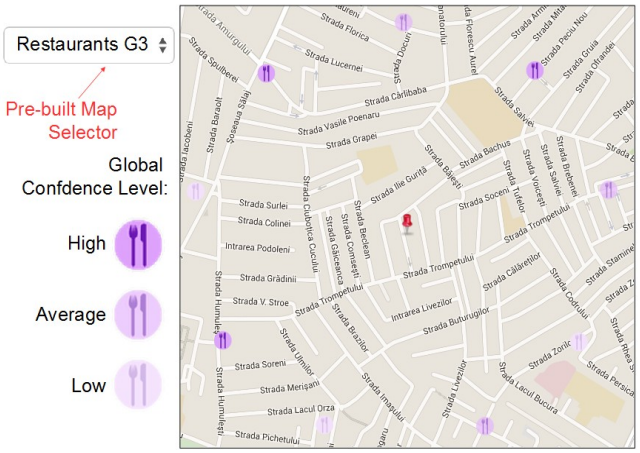


**Figure 2. New experiment. In mission 2, testers (in the middle) had to choose a restaurant between nine surrounding ones at the same distance. In this example for G3 testers only, icons indicate different confidence levels. Note that icons looked more contrasted on a screen.**

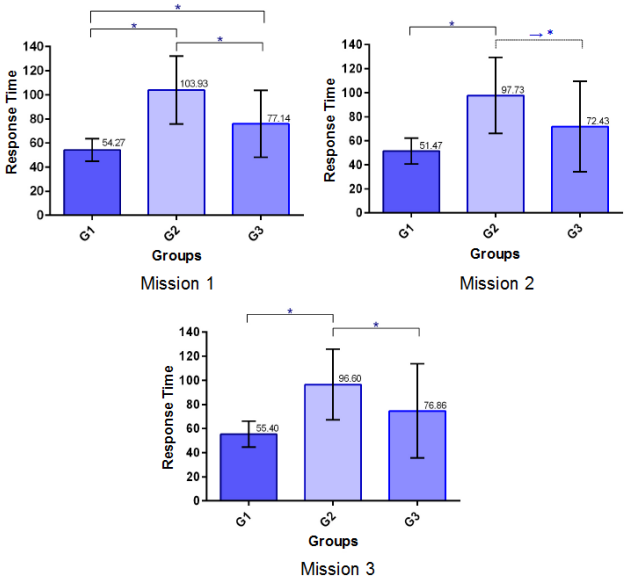


**Figure 3. Mean response times for the three missions. Black bars represent standard deviations. "*" indicates significant differences between groups, and "→ *" a trend towards significance (*p-value =.0569*).**

(83.3%). We observed that in a context of *trip planning* as well as in the context of *on site searching for POIs*: price and users' comments are the most important criteria when looking for restaurants or accommodation, and opening hours and price are the most important criteria when looking for a POI with an activity (e.g., a museum).

Then, we implemented a prototype to simulate a cartographic service in two contexts: planning a tourist trip, and on site looking for POIs. New testers were divided into three groups: a first group using a cartographic service with no uncertainty information (control group, G1, *N=15*), a second group with POIs having the same uncertainty information for all POIs (G2, *N=15*), and a third group with varying levels of uncertainty information (G3, *N=15*). We simulated three missions: 1) testers were asked to imagine they wanted to plan their next holiday trip in Bucharest, and to find an hotel, 2) testers had to find a restaurant (Figure 2), 3) testers had to find a monument to visit. Prices and opening hours ranges had three levels (high/wide, average, low/narrow). We built maps portraying nine POIs which are the combination of the three prices/opening hours and the three confidence levels. We measured the response times (Figure 3).

We can observe that adding "source" providers information increases user's cognitive load (G2>G1) but this cognitive overload seems to be reduced by visualizing varying confidence levels (G1<G3<G2). We conclude that adding varying uncertainty visualization impacts user's choices and time to make them.

The three missions' objectives were not imposing the utilization of such information but users used it as a major criterion for their choices. Whatever the mission, almost 100% of G3 testers said they utilized the highest confidence level as the criterion for their choice. We conclude that uncertainty information is taken into account in user's decision.

We globally conclude that visualizing uncertainty is a useful additional feature for potential users, to design cartographic services which integrate POIs from different providers in the context of tourism.

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